Cross-calibration of UARS and Aura MLS HNO_3 data sets by means of ground-based millimeter-wave observations

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Atmospheric Sciences at Stony Brook

Aura Science Team Meeting 2010, Boulder, Colorado

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GOZCARDS (Global Ozone Chemistry and Related Trace gas Data Records for the Stratosphere) is a multiyear project part of NASA's **MEaSUREs** (Making Earth System data records for Use in Research Environments) Program aimed at developing a global, long-term Earth System Data Record (ESDR) of stratospheric constituents relevant to the issues of ozone decline. This data record will be based mainly on satellite measurements but ground-based observations can be critically used for assessing offsets between satellite data sets. GOZCARDS Nitric Acid (HNO_3) dataset will be derived from the NASA/JPL Microwave Limb Sounder (MLS) experiments (aboard the Upper Atmosphere Research Satellite (UARS) from 1991 to 2001, and on the Earth Observing System (EOS) Aura mission from 2004 to date). Linking UARS and Aura HNO_3 measurements to establish a unique data record is a challenge due to the large data gap and to the lack of other HNO_3 datasets, global or at the same site, spanning a sufficiently long time interval. Nevertheless we tried to cross calibrate UARS and Aura data sets using measurements obtained by the GBMS (Ground-Based Millimeter-wave Spectrometer), the only ground based instrument that carried out correlative profile observations with both the satellite experiments, although sampling different latitudes in different years.

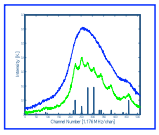
UARS MLS

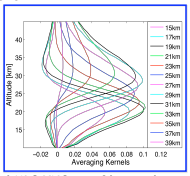
- UARS MLS acquired HNO_3 profiles from thermal emission lines near 205 GHz from September 1991 to August 2001, with increasingly sparse data after mid-1998 and a less consistently-retrieved dataset after mid-1997 (*Livesey* et al., 2003) .

- Latitudinal coverage of UARS MLS measurements extended from 34° on one side of the equator to 80° on the other, alternating 10 times per year between views of the northern and southern high latitudes.
- UARS MLS HNO_3 vertical profiles are considered reliable between 100 hPa and 4.6 hPa. Their vertical resolution varies with altitude from ~5 km to ~10 km.
- The estimated absolute accuracy is ~2-3 ppbv and the typical single profile precision ranges from 0.8 to 1.5 ppbv.
- UARS MLS version 6 data are used in this work.

GBMS

- GBMS has been operated starting from 1993 for more than 15 years at different sites.
- GBMS observes a cluster of HNO_3 emission lines centered at 269.10 GHz (strongly pressure broadened) superimposed to the wing of an ozone line

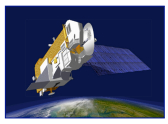




- In comparing GBMS and MLS HNO_3 profiles we have to account for the different vertical resolutions of the instruments.
MLS profiles (higher resolution) have to be "convolved" using the GBMS Averaging Kernels
- Even if the overall GBMS bandwidth (600 MHz) and spectral resolution (~1 MHz) allow retrievals of vertical profiles from ~15 km to ~50 km altitude, the Averaging Kernels show that retrieved profiles are reliable between ~15 km and ~32 km (with a vertical resolution of ~8 - 10 km and a 1 sigma uncertainty of ±15%).

Aura MLS

- Aura MLS has acquired HNO_3 profiles from thermal emission lines centered near 190 and 240 GHz from July 2004 to date.



- EOS Aura is in near-polar orbit. The MLS viewing geometry leads to data coverage from 82°S to 82°N latitude on every orbit.
- The Aura MLS HNO_3 data are recommended for scientific use over the range 215 to 3.2 hPa. The vertical resolution is ~3-5 km.
- Systematic uncertainties vary with altitude between 0.5 and 2 ppbv and the single-profile precision is ~0.7 ppbv throughout
- Aura MLS version 3.3 data are used; this version agrees better overall than v2.2 data with GBMS (and ACE-FTS) HNO_3 profiles

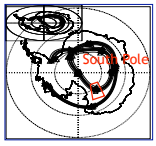
GBMS - UARS MLS intercomparison

GBMS observing site and periods:

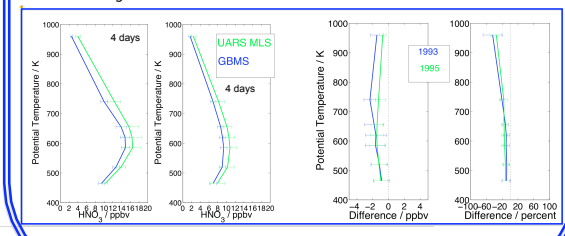
Amundsen-Scott Base
South Pole (90° S)

April 1993 - January 1994
March - November 1995

- Due to the final aim of this study we select periods with HNO_3 mixing ratio distributions at the South Pole not radically different from those observed at Testa Grigia and Thule. We focus this comparison on Antarctic Fall (from March to May), before the onset of significant denitrification.



- UARS MLS observations reached a southernmost latitude of 80°: the two sets of data are never co-located. A trajectory tracing technique is used to select MLS measurements at 7 PT levels (465 K, 520 K, 585 K, 620 K, 740 K, 960 K) (*Muscari et al.*, 2002). The selected MLS measurements are averaged together within a box of ±10° longitude and ±2.5° latitude.

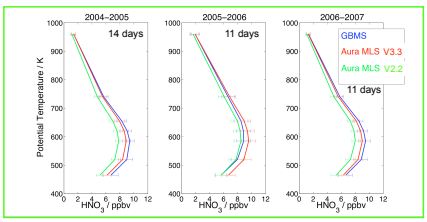


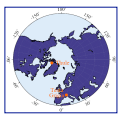
GBMS - Aura MLS intercomparison

GBMS observing sites and periods:

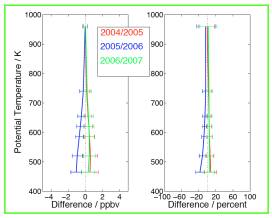
Testa Grigia
Italy
(45.9° N 7.7° E, 3500 m)

November 2004-March 2005
December 2005-March 2006
December 2006- March 2007



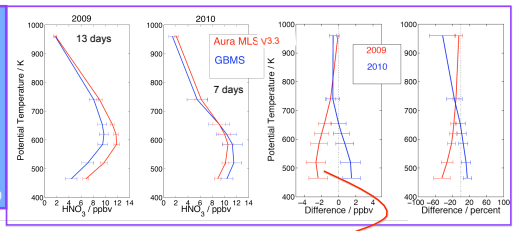


- Since EOS Aura has a near polar orbit, co-located measurements are available for both GBMS observing sites. Each GBMS observation is compared to the closest MLS profile, with coincidence criteria of ±10° longitude, ±2.5° latitude and ±12 h.



Thule Air Base
Greenland
(76.5° N 68.8° W)

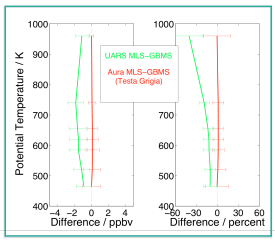
January- February 2009
January - February 2010



Thule 2009: poor agreement between GBMS and MLS data (in contrast with Testa Grigia). A preliminary comparison with ACE/FTS data suggests potential GBMS issues (instrument malfunctioning? ozone line wing background? The matter is under investigation)

UARS - Aura MLS cross-calibration

- At this stage of the project only the Testa Grigia and South Pole measurements have been considered for the cross-calibration of UARS and Aura MLS data sets. From these comparisons a slight high HNO_3 bias for UARS MLS versus Aura MLS might be inferred (albeit within the systematic uncertainties), but further investigations, including a review of comparisons between UARS MLS and balloon-borne HNO_3 retrievals from MkIV FTIR, are needed/planned.



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